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OF
THE NEW YORK ACADEMY OF SCIENCES

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Executive Director: EUNICE THOMAS MINER

UNIV. OF

GEOLOGIC PROBLEMS OF THE ARCTIC SLOPE OF ALASKA*

By RALPH L. MILLER†

The region here referred to as the Arctic Slope of Alaska includes the area between the Brooks Range divide and the Arctic Ocean. The Brooks Range is a prominent east-trending mountainous area extending almost completely across northern Alaska from the Arctic Ocean to the Canadian border. It separates a foothills and coastal plain area on the north from the broad Yukon lowland on the south. The total area of the Arctic Slope is on the order of 75,000 square miles.

Since almost the turn of the century, oil seeps have been known in the coastal plain area of the Arctic Slope. Enough was learned of the general geology through reconnaissance studies by both geologists and explorers to suggest that the known oil seeps might indicate the presence of appreciable reserves of petroleum in the Arctic Slope area. For this reason, approximately half of the Arctic Slope was set aside as Naval Petroleum Reserve No. 4 by Presidential proclamation in 1922. A small amount of additional geologic work, also of reconnaissance nature, was done in and near the Reserve in the next 20 years, but it was not until near the end of World War II that the strategic necessity of developing a source of petroleum in Alaska was deemed of sufficient importance to attempt intensive exploration of the oil potential of Naval Petroleum Reserve No. 4.

Starting in 1944, under the auspices of the Seabees, and continuing to the present time, a program of geologic work, geophysical work, and drilling has been carried on in and near NPR-4. Technical personnel gathered by the Seabees late in the war carried on the first year of the exploration effort. Thereafter, the Navy Oil Unit of the U. S. Geological Survey has done practically all the geologic work. A private contractor, the United Geophysical Co., has done most of the geophysical work, and another private contractor, Arctic Contractors, has done the construction work and drilling of wells.

The nature of the geologic work that is done is similar to what would be done in any other large, relatively unknown area of sedimentary rocks where the objective is finding the best places to drill for oil. It consists mainly in working out the stratigraphy and structure of the region. The means of accomplishing the desired field work is unusual, however, because of the climate and the remoteness of the area from centers of civilization and from established routes of transportation.

The effective field season, during which the snow mantle is absent and, thus, rock outcrops are visible, is from about June 1 to about September 1. On the average, therefore, field parties have 3 months a year in which to conduct their investigations. The logistics of supporting geologic field parties in the Arctic are involved and difficult, but, through experience, the major problems have been solved. In recent years dog teams have been used on one or two occasions, but this means of travel has limited application in modern geologic or other scientific studies.

Full-scale geologic field parties have been of three different types, based on the mode of transportation: (1) boat parties, (2) weasel parties, and (3) airborne parties. Boat parties carry their camp gear, supplies, and scientific equipment from camp site to camp site by boating down one of the major rivers, usually starting as far upstream as the river is navigable by wading and pulling the boat, then working downstream to the mouth of the river or to the farthest extent of good

* This paper was presented at the meeting of the Section, December 4, 1950. It was given by permission of the Director, U. S. Geological Survey.

† Geologist in charge, Navy Oil Unit, U. S. Geological Survey.

areas of rock outcrop. All geologic exposures within walking distance of the river are visited and mapped or studied by the geologists of a boat party. Weasel parties make use of the light-weight, semi-amphibious tracked vehicle known as the weasel, which, was developed in World War II. It is possible to travel almost anywhere in the Arctic Slope of Alaska in a weasel, provided gasoline and supplies are put out in advance at the necessary points along the route of travel and work. Airborne parties operate from camps located on lakes which may be reached by bush planes on skis when the lakes are frozen over or by bush planes on floats when the ice has melted. The area within walking distance of the lakes is then worked by geologists on foot. The geologists also take occasional "spike" trips, carrying minimum supplies in backpacks. They can thus extend the radius of the work to as much as 20 or 25 miles from a lake camp site.

In order that the most effective use be made of every day and almost every hour of the short field season, careful plans covering the minute details of the operation of a field party must be laid several months in advance. The areas of good rock exposures where pertinent geology is to be found are determined by a study of vertical and trimetrogon photographs of the general region to be worked. The location of desirable camp sites is picked, and the number of days' work from each camp site is estimated as accurately as possible. Thereafter, the quantities of food, fuel, and other supplies are determined for the entire season. These quantities are broken down into units known as caches, of which there may be from 6 to 12. The location of each cache is determined on aerial photographs, and the size of the cache in terms of fuel and food is likewise determined.

During the course of its season, a field party will move from the first cache to the last cache, picking up the necessary fuel, food, and the other supplies. Thus, it is saved the necessity of carrying along by weasel or boat or plane the large weight and volume of supplies needed for the entire 3-month season. The caches are put out at the designated places by bush planes on skis in April and May, and the fuel for weasel parties is dropped from large transport planes also at the designated places. Two parachutes per gasoline drum break the fall sufficiently so that the loss of gas drums is negligible.

The field party of geologists, assistants, and cook leaves the States about the middle of May and arrives on the Arctic Slope in late May. They are flown by bush plane to the cache where their weasels or boats and first increment of supplies are located. From then till the end of the season they are largely on their own, although they maintain radio contact with the base of operation and can call for additional material or for help in an emergency.

The geologic results per man and per dollar invested have been greatly increased by intensive use of aerial photographs. It was early recognized that the area to be studied was so large that it would be impossible for all of it to be visited and worked in detail by geologists on the ground. Hence, complete vertical photographic coverage of the petroleum reserve and adjacent areas was obtained, and, in addition, trimetrogon photographs were taken for use in making planimetric maps of the area. Finally, oblique photographs of prominent outcrops such as river bluffs were taken from planes flying close to the ground. These low-angle obliques have proved to be very time saving. They enable geologists to study and plot the results of detailed work, such as section measuring, directly on the photographs, and also to interpret the structure and at times the stratigraphy of outcrops that were impossible to visit for lack of time.

With all this photography available, the planning of a field program has been much simplified, and faster and more efficient field operations have been possible. Furthermore, through judicious interpretation of the vertical and oblique photographs, it has also been possible to extend the knowledge gained by work on the ground into adjacent

areas that were not visited. In addition, the geology of extensive areas has been worked directly from the photographs, utilizing the information visible in the photographs, to which is added information available from field geologists who have been in or near the area. At the present time, reasonably accurate geologic maps on a scale of 1 to 96,000 (for official use only) of all the foothills region of Naval Petroleum Reserve No. 4 and of some of the adjacent region have been made by this method.

The careful evaluation of the petroleum possibilities of the Arctic Slope of Alaska is not feasible by geologic methods alone. North of the Brooks Range, the Arctic Slope is divided into two regions of contrasting topography and geology. For about 90 miles north of the mountains, the region consists of elongate east-trending ridges and lowlands formed by folded and locally faulted Mesozoic sedimentary rocks. North of this Arctic Foothills province, however, is a coastal plain area about 80 miles wide that is practically flat and is covered by myriads of lakes. The Mesozoic rocks are here blanketed by a veneer of Pleistocene gravel and sand as much as 150 feet thick. In this region, there are practically no outcrops of pre-Pleistocene rocks, and the bedrock structures must be determined by geophysical methods. The stratigraphy of this area has been interpreted largely from studies of drill cores.

Magnetic, gravity, and seismic surveying have all been used in the coastal plain area, but greatest use has been made of seismic surveys to determine the structurally most suitable areas for locating wells. To date, most of the wells drilled have been in the coastal plain area and hence have been located by geophysical rather than by field geologic methods. The logistic problems involved in supporting seismic exploration and the drilling of wells in the Arctic are also complex and interesting but cannot be discussed here. The byproducts of the oil exploration program in Naval Petroleum Reserve No. 4, such as the knowledge of how to live, travel, do construction work, and carry on modern scientific investigations in the Arctic, have perhaps been almost as important as the information gained on the geology and oil possibilities of the area.

The results of the exploration are for the most part classified information, but, to the end of 1950, the Navy had announced the successful completion of small oil wells in two different regions and gas wells in a third region in the Reserve.

*SECTION OF BIOLOGY**

THE EFFECT OF ADRENAL CORTICAL STEROIDS AND DIET ON TUMOR GROWTH†

By GLADYS A. EMERSON‡

The administration of high doses of cortisone produced an atrophy of normal lymphoid tissue.[1–3] Cortisone therapy also retarded the growth of a lymphoid tumor in the mouse.[4] A regression of lymphosarcoma transplants was observed in some mice temporarily deprived of riboflavin.[5]

Experimental. Male mice 2–3 months of age of the C_3H strain were inoculated with lymphosarcoma (6 C_3H-ED). The tumors were allowed to grow for 10–11 days, at

* The Section of Physics and Chemistry held a meeting on December 5 at which a paper was presented by Frederick D. Rossini entitled "Excursion in Chemical Thermodynamics." No abstract of this paper has been received. The Section of Biology held a meeting on December 11 at which a paper was presented by Richard Smith entitled "Studies of Yellow Fever in the South American Rain Forest." No abstract of this paper has been received. The Sections of Psychology, Anthropology, Oceanography and Meteorology, and Mathematics and Engineering, and the Division of Mycology did not meet during December.

† This paper, illustrated with lantern slides, was one of five presented at a symposium entitled "Recent Experimental Studies with ACTH, Cortisone, and Related Steroids" held by the Section of Biology on November 13, 1950. Abstracts of three of the other papers were published in the December TRANSACTIONS.

‡ Merck Institute for Therapeutic Research, Rahway, N. J.

which time the animals were segregated into groups of 10 mice each with tumors approximating the same average size. Some of the mice were continued on the natural food ration, while others were transferred to a diet deficient in riboflavin. The groups were further subdivided into control (untreated) and experimental groups. The subcutaneous administration of 1 mg. of cortisone daily for a period of 7 days resulted in an almost complete regression of the tumor in the riboflavin-deficient mice, while measurable tumors persisted in animals receiving the same dosage of cortisone, but maintained on a natural food ration (TABLE 1). These results indicate that cortisone acetate was more effective in retarding the growth of lymphosarcoma transplants in mice on a riboflavin-deficient than on a stock diet.

Similarly, cortisone acetate (1 mg. s.c. daily for 7 days) effected a regression of tumor transplants in mice maintained on the riboflavin-deficient diet but supplemented with 4–8 γ of riboflavin daily.

The influence of graded doses of cortisone upon body weight and upon the weights of the spleen and thymus was determined in normal C_3H mice (av. wt. 20 gm.) maintained on a stock or on a riboflavin-deficient ration. This test likewise was extended over a 7-day period. The degree of riboflavin deficiency was not sufficiently severe to bring about a decline in weight in the untreated controls. Weight losses were observed in the animals in both dietary groups receiving 500 γ or 1 mg. of cortisone. Riboflavin deficiency alone caused a regression of the thymus. Furthermore, this organ was more sensitive to cortisone than was the spleen. Regression approaching the maximal was produced on either diet by 150–

TABLE 1

THE EFFECT OF DIET UPON THE RESPONSE OF LYMPHOSARCOMA TRANSPLANTS TO GRADED DOSES OF CORTISONE ACETATE

Days on test *	*0*†	*3*	*5*	*7*
		Volume of tumor—cm³		
Stock diet				
Controls	3.35	14.98	17.08	27.66
500γ cortisone acetate s.c. daily	3.16	5.80	4.23	4.00
1000γ cortisone acetate s.c. daily	3.99	3.42	3.35	3.25
Riboflavin deficient diet				
Controls	3.45	11.09	14.04	15.45
250γ cortisone acetate s.c. daily	3.83	5.19	6.31	9.37
500γ cortisone acetate s.c. daily	3.93	5.82	5.80	3.70
1000γ cortisone acetate s.c. daily	4.14	1.39	0.90	<1

* Groups of 10 male mice each.
† 0 days = 11 days post-transplant (10,000 cells).

TABLE 2

THE EFFECT OF GRADED DOSES OF CORTISONE UPON BODY AND ORGAN WEIGHTS OF MICE*

	Change in body weight (gm.)		*Weight (mg.)*			
	Diet		*Thymus*		*Spleen*	
Groups of 5 male mice each	*stock*	*riboflavin-deficient*	*stock*	*riboflavin-deficient*	*stock*	*riboflavin-deficient*
Controls (untreated)	+2.8	+0.6	46.1	26.5	92.2	93.4
Cortisone acetate (s.c.) daily for 7 days						
γ						
75	+3.6	+1.4	17.7	15.7	74.3	80.2
150	+2.5	+1.4	7.8	6.2	61.7	44.1
250	+0.7	0	6.3	4.0	36.2	35.3
500	−2.0	−3.0	3.5	3.3	33.1	24.1
1000	−5.0	−4.0	1.4	2.6	31.6	33.1

* Groups of 5 male mice each.

250 γ of cortisone acetate daily (TABLE 2). The thymus and spleen appeared to be more sensitive to treatment with cortisone than was the transplanted tumor, suggesting that the activity was possibly proportional to the weight of the tissue involved.

Recent clinical reports[6] indicate that cortisone acetate was almost equally effective when administered in a single dose by the oral as by the subcutaneous route. Accordingly, a comparison was made of the activity of cortisone acetate when given orally and parenterally to mice with lymphosarcoma transplants. The results of these tests indicate that, under the conditions of this test, cortisone is 5–10 times more active when administered in a single dose by the parenteral (subcutaneous) than by the oral route (TABLE 3). Compound F* and cortisone acetate, when administered subcutaneously at a level of 250 γ daily, gave the same response: an arrest in tumor growth.

TABLE 3

COMPARATIVE ACTIVITIES OF PARENTERAL AND ORAL CORTISONE

*Days on test**	*0*†	*5*	*7*
	*Volume of tumor cm*³		
Test 1			
Controls (riboflavin deficient)	1.91	12.02	10.43
1 mg. Cortisone acetate (p.o.)	1.91	8.50	1.91
0.50 mg. cortisone acetate (s.c.)	1.91	1.34	<1
Test 2			
Controls (riboflavin deficient)	3.56	13.80	16.86
5 mg. cortisone acetate (p.o.)	3.27	1.0	<1

* Groups of 10 male mice each.
† 0 Days = 10 days post-transplant 10,000 cells.

* Kindly supplied by The Upjohn Laboratories, Kalamazoo, Michigan.

Compound A acetate was slightly less effective than cortisone as a carcinolytic agent. 21-Desoxycortisone appeared to possess a low order of activity when given at a level of 4 mg. per day. Dihydrocortisone acetate, pregnenolone, 21-acetoxypregnenolone, DCA, progesterone, 11-keto-progesterone, and 3,11-20-triketo,4,21-diacetoxy 17-hydroxypregnane were inactive when administered at a level of 1 mg. daily (subcutaneous) for 6 days.

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REPORT OF THE ANNUAL MEETING

December 6, 1950

The 133rd Annual Meeting of the Academy, for the election of Officers and Fellows, the presentation of reports, and the transaction of other business, was held at the Waldorf-Astoria Hotel on the evening of Wednesday, December 6, 1950.

The first order of business was devoted to the reports of the Officers and Committees of the Academy.

REPORTS OF OFFICERS AND COMMITTEES

Report of the Recording Secretary. The turn of events, during the past year, has launched the Academy on a new phase of its history. The inauguration of the new building last April, with a four-day celebration, and the accompanying increase of the momentum of activities, such as the program of outstanding meetings and conferences, the further expansion of membership, and the record established by the publication of twelve important monographs resulting from conferences, have brought the Academy sharply into focus as one of the world's outstanding learned institutions and have completed a year of record achievement.

The series of seventy-five conferences developed and held by the Academy since 1939 has become recognized throughout the world not only as an important contributing factor toward the progress of science but also as a reliable indicator of the nature of that progress.

The Members of the Academy should appreciate the significance of the standing which their society has achieved through this widespread recognition and should realize that this has been made possible as the direct result of their able participation in the conferences and regular Sectional meetings, together with their financial support and good will. Such an achievement calls for continued cooperation, unfailing interest and activity, and the continued financial support on the part of the Membership, so that the Academy's future usefulness and growth in its new home may be assured.

Due to the advantages afforded by being in our own building, and in response to the requests of a large number of investigators in this field, the new Section of Mathematics and Engineering was established in May, 1950. This Section was organized through the efforts of Doctor Abraham Slavin, with the cooperation of Doctors David B. Steinman and Donald Herr. It has also been possible for the Section of Oceanography and Meteorology to hold evening sectional meetings, instead of being limited to occasional conferences. The facilities of the Academy meeting rooms are being extended to other qualified societies, and a number are now regularly meeting in the Building.

The Chairmen of the conferences as well as the Chairmen and Secretaries of the various Section and the Division of Mycology deserve exceptional credit and thanks for their able development of the series of interesting and important meetings held this year. We are grateful to the speakers for the high caliber of their scientific papers.

Forty-nine Sectional meetings and four conferences were held this past year, at which 156 important scientific papers were presented and discussed. The following conferences have been held since the previous Annual Meeting:

"The Growth, Replacement and Types of Hair," Chairmen, James B. Hamilton, Long Island College of Medicine, Brooklyn, New York and Amos E. Light, The Wellcome Research Laboratories, Tuckahoe, New York.

"The Fundamental Aspects of Lubrication," Chairman, Otto Beeck, Shell Development Company, Emeryville, California.

"Terramycin," Chairman, Chester S. Keefer, Evans Memorial Hospital, Boston, Massachusetts.

"Leprosy," Chairman, Emanuel Grünberg, Hoffmann-La Roche, Inc. Nutley, New Jersey.

During the past year, 917 new Members and 17 reinstatements were added to our rolls, as follows: 7 Honorary Life Members, 14 Active Life Members, 46 Sustaining Members, 813 Annual Active Members and 37 Student Members. Twenty-five Annual Members were transferred to Life Membership by payment of the Life Membership Fee. Twenty-three transfers were effected in the Annual Classes.

The Academy lost by death 3 Honorary Life Members, 4 Active Life Members, 2 Sustaining Members and 18 Annual Active Members. One hundred sixty-four resignations were accepted, 148 names were dropped for non-payment of dues or for not having qualified for Membership.

The Academy now stands with a net gain of 595 Members. There are, at present, upon the rolls of the Academy 5,447 Members, of whom 701 are Fellows, classified as follows: 3 Benefactors; 3 Patrons; 56 Honorary Life Members; 363 Active Life Members; 199 Annual Sustaining Members; 4,695 Annual Active Members; 128 Annual Student Members.

Report of the Corresponding Secretary. The Corresponding Secretary noted with regret the deaths of three Honorary Life Members. These deaths reduced the enrollment of the Honorary Life Membership Class to 56 as of October 31, 1950. The election of ten scientists to this class at this Annual Meeting brings the total of the Honorary Life Membership to 66.

Report of the Editor. During the fiscal year ending November 30, 1950, The New York Academy of Sciences has issued 12 ANNALS monographs, comprising a total of 2,502 pages. Included in these are 293 papers by 475 authors. The TRANSACTIONS (280 pages) brings the total pagination to 2,782.

The list of publications is as follows:

ANNALS

Volume 52, Article 3, "Vitamin E" (67 papers), by K. E. Mason *et al.* Pages 63–428. Dated October 31, 1949, but not received until after November 1, 1949.

Volume 52, Article 4, "Coccidiosis" (28 papers), by S. Brackett *et al.* Pages 429–624. Published November 10, 1949.

Volume 52, Article 5, "The Chemotherapy of Tuberculosis—The Experimental Approach" (19 papers), by Geoffrey Rake *et al.* Pages 625–788. Published December 14, 1949.

Volume 50, Article 7, "Allergy" (10 papers), by A. F. Coca *et al.* Pages 679–814. Published December 26, 1949.

Volume 50, Article 8, "Structure in Relation to Cellular Function" (13 papers), by Robert Chambers *et al.* Pages 815–1012. Published February 24, 1950.

Volume 52, Article 6, "The Place of Statistical Methods in Biological and Chemical Experimentation" (16 papers), by E. J. De Beer *et al.* Pages 789–942. Published March 10, 1950.

Volume 50, Article 9, "Antihistamine Agents in Allergy" (15 papers), by F. F. Yonkman *et al.* Pages 1013–1208. Published April 28, 1950.

Volume 52, Article 7, "The Ground Substance of the Mesenchyme and Hyaluronidase" (39 papers), by F. Duran-Reynals *et al.* Pages 943–1196. Published May 31, 1950.

Volume 52, Article 8, "Antimetabolites" (13 papers), by D. W. Woolley *et al.* Pages 1197–1378. Published July 7, 1950.

Volume 53, Article 1, "Mechanism and Evaluation of Antisep-

tics" (24 papers), by H. L. Davis *et al.* Pages 1–220. Published August 30, 1950.
Volume 50, Article 10, "Medical Mycology" (16 papers), by Frederick Reiss *et al.* Pages 1209–1404. Published September 6, 1950.
Volume 53, Article 2, "Terramycin" (33 papers), by C. S. Keefer *et al.* Pages 221–460. Published September 15, 1950.

TRANSACTIONS

Series II, Volume 12, Numbers 1–8, consisting of 280 pages, was completed, printed, and distributed from November, 1949, to June, 1950, inclusive.

In addition to the articles published during the fiscal year, the following have been printed since its close or are now in press and will be issued during the next two months:

Volume 51, Article 6, "Methodology and Techniques for the Study of Animal Societies" (12 papers), by J. P. Scott *et al.* Pages 1001–1122. Published November 7, 1950.
Volume 51, Article 7, "Human Engineering" (13 papers), by L. E. Abt *et al.*
Volume 51, Article 8, "The Mechanisms of Cell Division" (16 papers), by M. J. Kopac *et al.*
Volume 53, Article 3, "The Growth, Replacement, and Types of Hair" (28 papers), by J. B. Hamilton *et al.*
Volume 50, Article 6, "The Adrenal Cortex" (14 papers), by R. Gaunt *et al.* (second printing).

SPECIAL PUBLICATIONS. A second printing of the Second Edition of "Climate and Evolution," by W. D. Matthew, is in the hands of the printer and will be published by the end of the calendar year.

THE SCIENTIFIC SURVEY OF PORTO RICO, Volume XVII, Part 1, "The Pelecypoda or Bivalve Mollusks of Porto Rico," by R. A. McLean, will be published within two months.

During the period November 1, 1949–October 31, 1950, the Academy has distributed 143,094 separate publications and 10,069 complete volumes of the various series, as follows:

Annals	*Separate Numbers*	*Volumes*
Gratis: Members	27,622	
Gratis: Authors, reviews, exchanges, and donors	10,124	44
Sales	11,567	144
Authors Reprints	70,225	
Special Publications, Volumes III–IV		
Gratis: Authors, reviews		6
Sales		229
Scientific Survey of Porto Rico		
Gratis	104	
Sales	296	
Transactions, Series II		
Gratis: Members, authors, exchanges and reviews	6,640	4,790
Sales	501	68
Authors Reprints	8,875	
Bulletins and Monthly Program:		
Gratis: Members, Affiliated Societies' Members, reviews and gratis	7,140	4,788
	143,094	10,069

The total cost value of publications distributed gratis to the Members, authors, donors, reviewers and exchange institutions is $47,590.78.

Report of the Treasurer. The Academy has made important strides forward in its development during the past year. During this period, the Academy has acquired, altered for occupancy, and furnished its new home and has sponsored the finest series of conferences and the most extensive publication program of Annals and Transactions in many years.

This remarkable record has been made possible financially only through the loyal support of the members of the Academy and the generous contributions and grants of friends.

The Academy wishes to express its deep appreciation for contributions to the Building and Sustaining Fund and for the generous Grants-in-Aid which permitted the fulfillment of the ambitious publications program during the past year.

Capital expenditures for building alterations and furnishings amounting to $51,412.10 were defrayed from contributions to the Building Fund. In addition, Mr. and Mrs. Woolworth donated many of the furnishings, such as draperies, furniture, and other items of equipment, which have an appraisal value of $10,000. The expenses of moving from the Museum to our new building were generously covered by a friend of the Academy.

The total property value of the building and its equipment now stands at $476,585.65, of which $24,305.02 represents the value of the equipment. We have against this a mortgage of $195,449.19, on which we pay $15,000 per year to cover interest and amortization.

The contributions and income credited to the Building Fund as reported October 13, 1949 amounted to $80,134.22. During the past fiscal year, $12,505.52 has been added to this account. This additional amount is greatly appreciated, but it should be increased. The Membership is asked to encourage additional contributions to this Fund through added Life Memberships, Patronships, Benefactorships, and contributions.

The financial picture presented for the Academy's operations under General and Special Funds is one of healthy growth and development. However, it must be realized that these funds are derived from current sources of income. Permit me to review briefly our sources of income and expenses. Out of a total income of $126,768.27, the Academy received only $2,933.91 as dividends from its slender Endowment Funds, while the remainder was derived from current sources, such as Membership dues $51,301.67 (40 per cent), sales of publications and miscellaneous income $40,817.12 (32 per cent), and $31,715.57 applied from Grants-in-Aid (25 per cent).

This income was applied to salaries $40,879.70 (32 per cent), General Administration expenses and cost of distributing publications $16,048.09 (12 per cent), Sectional Meetings and Conferences $4,729.40 (4 per cent), and the prime printing cost for Publications $58,273.88 (46 per cent).

It is important to note that under publications cost is included only the prime printing costs, not the cost of editorial work or distribution and that this expenditure of over $58,000 constitutes nearly 50 per cent of the operating expenses. This is a remarkable record of achievement of Academy publications for any single year.

A net income of $6,837.20 (6 per cent) was realized, which reduced the operating deficit of 1949 to $3,503.51. However, a year-end transfer of charges of $7,379.66 for equipment purchases from General

Funds to Capital Account of the Building Fund increased the deficit as of October 31, 1950 to $10,883.17.

It is therefore clearly evident that at present we are dependent upon the income available from year to year to safeguard and guarantee continuance of the present program of expanding services by the Academy to the Membership and to Science. The loyalty, financial support, and enthusiastic endorsement by the entire Membership must be unqualifiedly assured in order that the ultimate aim of scientific research, the presentation and discussion of its results and the publication and dissemination of scientific information as developed in the Academy's program of activities may be attained. It is important that the Academy keep all its facilities operating at full capacity, so that we may fulfill our present role in the scientific world.

The most pressing financial needs for the future are: (1) enlargement of our capital funds; (2) development of plans for financing a much needed auditorium; (3) adequate support for the expenses of our conferences and their resulting publications; and (until such support is obtained) (4) income from enlarging our membership and expanding our sales of publications. These are all important goals toward which we must aim to consolidate and achieve our financial program to protect the Academy from retrogression and to preserve its established standards of leadership and independence.

The assurance of success in attaining these goals will depend primarily upon the financial support of income from Members' Dues and Sales of Publications, but this must be supplemented by contributions, through gifts and grants-in-aid from Corporations, Foundations, and friends interested in the welfare of the Academy.

The following pages present the auditor's report, which outlines the Academy's financial during the fiscal period ending October 31, 1950. The books of accounting have been checked and certified by the firm of Peat, Marwick, Mitchell and Company, Certified Public Accountants. The property of the Academy has been verified by the auditors and by the Finance Committee. This report has been approved by the Finance Committee as of December 1, 1950, as provided in the By-Laws.

Report of the Auditors.

PEAT, MARWICK, MITCHELL & CO.
CERTIFIED PUBLIC ACCOUNTANTS
SEVENTY PINE STREET
NEW YORK 5, N.Y.

Accountants' Report

To the Finance Committee,
The New York Academy of Sciences,
New York, N. Y.

We have examined the balance sheet of The New York Academy of Sciences as of October 13, 1950 and the related statement of income and expenditure for the year then ended. Our examination was made in accordance with generally accepted auditing standards and included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

The cash and bank balances have been confirmed by count or by certificate obtained directly from the depositary.

We did not confirm the members' dues or the pledges receivable by communication with the respective members or pledgors but we reviewed the related accounts as to age and collectibility with the Executive Director and from the information available appropriate allowances have been made for probable losses.

We communicated with all debtors on accounts receivable for publications by mailing the Academy's statements for the month of October accompanied by a request that we be notified of any exceptions. The exceptions reported were explained to our satisfaction. The accounts were reviewed as to age and collectibility and, in our opinion, reasonable allowance has been made for probable losses.

The books and publications on hand at October 31, 1950 have not been reflected in the accompanying balance sheet as it is the policy of the Academy to charge to expense the publication costs as incurred.

The marketable securities were inspected and the income therefrom was confirmed by reference to independent sources.

We inspected the deed to the real estate at 2 East 63rd Street, New York, contributed to the Academy in 1949. It is carried in the balance sheet at the valuation as assessed by the City of New York for real estate tax purposes, as of the date of the contribution. The additions to furniture, fixtures and equipment include furnishings contributed to which a value of $10,000.00 has been assigned. We inspected approved vouchers in support of other additions and improvements. Consistent with the practice usually followed by similar organizations, the Academy does not provide for depreciation of the furniture, fixtures and equipment or of the building.

All liabilities of which we obtained knowledge in the course of our examinations have received appropriate recognition.

In our opinion, the accompanying balance sheet and statement of income and expenditure present fairly the financial position of The New York Academy of Sciences at October 31, 1950 and the results of its operations for the year then ended, in conformity with generally accepted accounting principles.

/s/ Peat, Marwick, Mitchell & Co.

New York, N. Y.
November 24, 1950.

THE NEW YORK ACADEMY OF SCIENCES

Balance Sheet

As of October 31, 1950

GENERAL FUND

ASSETS		LIABILITIES		
Cash in The Chase National Bank	$ 40.61	Accounts Payable		$13,619.57
Members' Dues Receivable, less allowance for doubtful dues $1,360.00	490.00	Deferred Income:		
		Members' dues for calendar year 1950—unearned	$8,810.83	
Accounts Receivable for Publications, less allowance for doubtful accounts $400.00	4,633.76	Members' dues for calendar year 1951—paid in advance	580.00	9,390.83
Prepaid Expenses	229.81	Due to Endowment Funds		
Due from Temporary Funds	1,796.53	General Fund (deficit):		
Due from Building Fund	4,998.52	Balance as of October 31, 1949	10,340.71	
		Furniture, fixtures, and equip., at cost, transferred to the Building Fund	7,379.66	
			17,720.37	
		Less Excess of income over expenditures for year ended on 10/31/50, per attached statement	6,837.20	(10,883.17)
	$12,189.23			$12,189.23

TEMPORARY FUNDS

Cash in The Chase National Bank	5,071.26	Accounts Payable		9,573.99
Due from Building Fund	15,800.50	Due to General Fund $1796.53, and Endowment Funds $39.36		1,835.89
		Unexpended Grants-in-Aid:		
		Balance as of October 31, 1949	18,746.05	
		Grants-in-Aid received	22,431.40	
			41,177.45	
		Less Publications costs of $29,374.29, and other expenditures of $2,341.28	31,715.57	9,461.88
	$20,871.76			$20,871.76

ENDOWMENT FUNDS AND MORRISON PRIZE FUND

ENDOWMENT FUNDS AND MORRISON PRIZE FUND

Cash in The Chase National Bank	$ 325.93	Endowment Funds and Morrison Prize Fund:		
Marketable Securities—stated at cost or quoted price at date of contribution (market value at 10/31/50 $59,445.73)	56,292.67	Balance as of October 31, 1949		$92,814.72
		Contributions received		3,483.21
		Net capital gain on sales of securities		296.60
Due from General Fund	62.00	Income from securities per accompanying statement		525.43
Due from Temporary Funds	39.36			97,119.96
Due from Building Fund	16,499.50	Prizes awarded	400.00	
		Funds transferred to Bldg. Fund	23,500.50	23,900.50
	$ 73,219.46			$73,219.46

BUILDING FUND AND SUSTAINING FUND

Cash on hand	$ 2.68	Accrued interest on mortgage		$1,465.86
Pledges Receivable, less allowance for doubtful pledges $1,200.00	7,216.83	Mortgage on real estate, 4½%, payable $3,750 quarterly (for principal and interest), balance due 11/1/59		195,449.19
Marketable Securities—stated at cost (market value at 10/31/50 $26,255.50)	17,565.00	Due to General Fund $4,998.52; Temporary Fund $15,800.50; Endowment Funds $16,499.50		37,298.52
Furniture, Fixtures, and Equipment—comprising contributed furnishings at assigned value of $10,000, balance at cost	24,305.02	Unexpended contribution for furniture and fixtures		156.30
Real Estate at 2 East 63rd Street, New York, at assessed valuation at date of contribution, and improvements at cost:		Building Fund and Sustaining Fund:		
		Balance as of October 31, 1949	$258,756.95	
		Contributions of furnishings		
		at assigned value	10,000.00	
		at purchased cost	1,193.17	
Land $200,000.00		Transfers from other Funds	30,880.16	
Building 225,000.00			300,830.28	
Improvements 27,280.63	452,280.63			
Prepaid Expenses	194.03	Real estate acquisition costs	(17,904.63)	
		Excess of expenditures over income, year ended 10/31/50 per accompanying statement	(15,731.33)	267,194.32
	$501,564.19			$501,564.19
Total	607,844.64	*Total*		607,844.64
Deduct: Intra-fund balances	39,196.41	Deduct: Intra-fund balances		39,196.41
Net Total	$568,648.23	*Net Total*		$568,648.23

THE NEW YORK ACADEMY OF SCIENCES

Statement of Income and Expenditures

For the Year ended October 31, 1950

GENERAL FUND

Income:		
Membership dues		$51,301.67
Sales of publications		39,585.94
Income from securities of Endowment Funds		2,933.91
Sales of tickets for conference and annual dinner		932.00
Contribution		100.00
Library exchange and miscellaneous income		199.18
		95,052.70
Expenditures:		
Salaries	$40,879.70	
Publication costs (exclusive of costs charged to Grants-in-Aid)	26,558.31	
Distribution of publications	1,566.92	
Postage	8,797.49	
Telephone	1,161.03	
Membership expansion	723.42	
Annual dinner and meeting expenses	1,378.00	
Conferences and sectional meeting expenses	2,840.80	
Museum service charges	510.60	
Insurance	79.52	
General office expenses	1,959.71	
	86,455.50	
Provision for doubtful dues $1,360.00, and doubtful accounts receivable $400.00	1,760.00	
		88,215.50
Excess of Income over Expenditures		$ 6,837.20

ENDOWMENT FUND AND MORRISON PRIZE FUND

Income from Securities	$ 3,459.34
Less amount credited to General Fund, as above	2,933.91
Amount Retained	$ 525.43

BUILDING FUND AND SUSTAINING FUND

Income:		
Contributions		$ 7,530.00
Income from securities		3,192.37
Gain on sale of securities		1,783.15
		12,505.52
Expenditures:		
Building operating expenses	$8,485.10	
Salaries and expenses of Fund Drive	7,074.37	
House Opening expenses	2,500.00	
Interest on mortgage	8,977.38	
	27,036.85	
Provision for doubtful pledges	1,200.00	
		28,236.85
Excess of Expenditures over Income		$15,731.33

AWARDS OF PRIZES

Two Prizes of $200 each in The A. Cressy Morrison Prize Competition in Natural Science were offered for the year 1950.

Eighteen papers, the majority of excellent quality, were entered this year. After careful and conscientious examination of these papers and consultation with other scientific specialists, the Committee, as authorized by the Council of the Academy, makes the following awards:

(1) A prize of $200 to the paper entitled "A Theorem in Electromagnetics, With Useful Applications to Computing Devices," by Donald Lincoln Herr, Adjunct Professor of Electrical Engineering, Polytechnic Institute of Brooklyn, New York, and a Member of the staff of the Hughes Aircraft Company, Culver City, California and a Member of the Advisory Board of the Research and Development Laboratories of that Company.

(2) A prize of $200 to the paper entitled "An Experimental Analysis of Morphogenesis in *Stentor coeruleus*," by Paul B. Weisz, Department of Biology, Brown University, Providence, Rhode Island.

(3) Honorable Mention to the paper entitled "The Action of Salts of Zirconium and Other Metals on Plutonium and Yttrium Distribution and Excretion," by Marcia R. White and Jack Schubert, Division of Biological and Medical Research, Argonne National Laboratory, Chicago, Illinois.

The Committee is pleased to announce the renewal of the two A. Cressy Morrison Prizes in Natural Science of $200 each for the year 1951, for the two most acceptable papers entered in competition, in a field of natural science covered by the Academy and its Affiliated Societies. This is now an annual renewal of these prizes due to the establishment, in 1949, of the A. Cressy Morrison Prize Fund, under the auspices of The New York Academy of Sciences. Announcement of these awards will be made at the Annual Meeting of the Academy to be held in December, 1951.

Announcement is also made, at this time, that a George Frederick Kunz Prize of $200, offered for the most acceptable paper entered in competition in the fields of Geology and Mineralogy, will be awarded at the Annual Meeting of the Academy to be held in December, 1951.*

Through the generosity of Mr. A. Cressy Morrison, and with the authority of the Council, a Prize of $500 is offered for the paper, adjudged by the Council of the Academy, to be the most meritorious, original paper, entered in competition for this Prize, and relating to the subject of the sources of solar and stellar energy. This Prize will be awarded at the Annual Meeting of the Academy to be held in December, 1952.

* Further details and the specific conditions governing these competitions appear on p. 123 of this issue.

ELECTION OF FELLOWS AND HONORARY LIFE MEMBERS

The following Members were elected to Fellowship:

Algire, Glenn H., M.D.
Angrist, Alfred A., M.D.
Anigstein, Ludvik, Ph.D., M.D.
Anslow, William P., Jr., Ph.D.
Ayres, Gilbert B., Ph.D.
Baehr, George, M.D.
Batson, Herbert C., Ph.D.
Becks, Hermann, M.D.
Bergmann, Werner, Ph.D.
Bieter, Raymond N., Ph.D.
Bishop, David W., Ph.D.
Black, Lindsay MacLeod, Ph.D.
Bondi, Amedeo, Ph.D.
Boudreau, Frank G., M.D., LL.D.
Bunney, William E., Ph.D.
Burchenal, Joseph H., M.D.
Burkholder, Paul R., S.D., Ph.D.
Carruthers, Christopher, Ph.D.
Coghill, Robert D., Ph.D.
Cole, William H., Ph.D.
Curme, George O., Jr., D.Sc.
De Bodo, Richard C., M.D.
De Gara, Paul F., M.D.
Demerec, M., Ph.D.
Dobriner, Konrad, M.D.
Eversole, Wilburn J., Ph.D.
Falk, Henry C., M.D.
Fejos, Paul, M.D.
Felton, Lloyd D., M.D.
Folch-Pi, Jordi, M.D.
Foot, Nathan Chandler, M.D.
Furman, N. Howell, Ph.D.
Gross, Paul M., Ph.D.
Guzman, Leonardo, M.D.
Hallowell, A. Irving, Ph.D.
Harris, T. N., M.D.
Herr, Donald, E.E.
Hobby, Gladys, L., Ph.D.
Hohenstein, Walter P., Ph.D.
Holland, Maurice
Hueper, Wilhelm C., M.D.
Johnson, Frank H., Ph.D.
Kleinberg, William, Ph.D.
Kropa, Edward L., Ph.D.
Kuh, Erwin, Ph.D.
Kunitz, Moses, Ph.D.
Kupperman, Herbert S., Ph.D., M.D.
Kyrides, Lucas P., Sc.D.
L'Esperance, Elise S., M.D.
Levin, Louis, Ph.D.
Li, Choh Hao, Ph.D.
Long, Margaret E., Ph.D.
MacCardle, Ross C., Ph.D.
MacColl, Leroy A., Ph.D.
McGavack, Thomas Hodge, M.D.
Mackenzie, Cosmo Glenn, Sc.D.
McLachlan, Dan, Jr., Ph.D.
McShan, William Hartford, Ph.D.
Merck, George W., M.S.
Miller, Samuel C., D.D.S
Neuwirth, Isaac, Ph.D.
Noyes, W. Albert, Sc.D.
Nungester, Walter, J., M.D., Sc.D.
Oleson, J.J., Ph.D.
Osborn, Clinton M., Ph.D.
O'Shaugnessy, M. Thomas Jr., Ph.D.
Page, Irvine H., M.D.
Paine, Harold W., Ph.D.

Parker, Robert Prescott, Ph.D.
Parks, W. George, Ph.D.
Pincus, Gregory, Sc.D.
Pressman, David, Ph.D.
Price, Donald, Ph.D.
Rabi, I.I., Ph.D., D.Sc.
Racker, Efraim, M.D.
Rassweiler, Clifford Fred, Ph.D., Sc.D.
Rodden, Clement J., M.S.
Roepke, Raymond R., Ph.D.
Ross, John, Ph.D.
Rouse, Irving, Ph.D.
Schoenbach, Emanuel B., M.D.
Seifter, Joseph, M.D.
Sevag, Manasseh G., Ph.D.
Shepard, Norman A., Ph.D.
Slavin, Abraham, Eng.Sc.D.
Snapper, Isidore, M.D.
Sobel, Albert E., Ph.D.
Sperry, Warren M., Ph.D.
Spiegelman, Sol, Ph.D.
Steele, James H., D.V.M.
Steinman, D. B., Ph.D., Sc.D.
Stout, Arthur P., M.D.
Taylor, Alfred, Ph.D.
Thorek, Max, M.D., LL.D.
Trunnell, J. B., M.D.
Weisz, Paul B., Ph.D.
Werne, Jacob, M.D.
Wetmore, Ralph H., D.Sc., Ph.D.
White, Abraham, Ph.D.
White, Harold J., Sc.D.
Wilhelmi, Alfred E., Ph.D.
Woolley, George W., Ph.D.
Yadoff, Oleg, D.Sc.
Youden, William J., Ph.D.
Zarrow, M. X., Ph.D.
Zimmerman, H. M., M.D.

Honorary Life Membership was conferred upon the following eminent scientists:

William Thomas Astbury, Fellow, Royal Society; Fellow, Institute of Physics; Professor of Biomolecular Structure, University of Leeds, England.

Charles Herbert Best, Physiology, Director, Banting & Best, Department of Medical Research, University of Toronto, Toronto, Ont., Canada.

Frank MacFarlane Burnet, Fellow, Royal Society; Director, Walter and Eliza Hall Institute, Melbourne, Australia.

James Bertram Collip, Biochemistry, Dean, Faculty of Medicine and Professor of Medical Research, University of Western Ontario.

Eduardo Cruz-Coke, Professor of Biochemistry, University of Santiago Medical School; Senator, 1941–49; Member of the Medical Societies of Chile, Buenos Aires, Lima, and New York and Biochemistry Society of London.

Bernardo Houssay, Director, Institute of Physiology, Buenos Aires Hospital; President, Argentine Pharmacy Commission; Co-winner, Nobel Prize, 1947; Vice Dean, Buenos Aires Medical School.

Harold Jeffreys, M.A., D.Sc., F.R.S., Foreign Member, National Academy of Sciences; Plumian Professor, St. Johns College, Cambridge University.

Hugo Rudolph Kruyt, D.S.C., Professor, University of Utrecht; Vice-President, Netherland Royal Academy of Sciences; President, National Research Council; Member of Royal Academy of Sciences of Amsterdam and Royal Flemish Academy in Brussels.

John Runnstrom, Ph.D., M.D., Director, Wenner-Gren Institute; Professor, Stockholm University; Visiting Professor, University of Pennsylvania 1950–52; Harvey Lectures, Jessup Lectures, 1950–51.

Nevil Vincent Sidgwick, Fellow of The Royal Society 1922; M. A. Oxon; Sc.D., Tubingen; Hon.D.Sc. University of Leeds; Hon. LL.D. University of Liverpool; Fellow and formerly Tutor of Lincoln College, Oxford.

ELECTION OF OFFICERS

The following officers were elected for the year 1951:

President

WILLIS A. GIBBONS

Vice-Presidents

JOHN RAY DUNNING
WALTER S. ROOT

Chairmen of Sections

SIDNEY PAIGE
ELI D. GOLDSMITH
THOMAS N. JENKINS
PAUL FEJOS
CHARLES O. BECKMANN
WILLIAM L. DONN
ABRAHAM SLAVIN

Chairman of Di ision

BENJAMIN M. DUGGAR

Recording Secretary

HARRY A. CHARIPPER

Corresponding Secretary

JAMES B. ALLISON

Treasurer

DONALD M. BENJAMIN

Editor

ROY WALDO MINER

Councilors (1951–1953)

EDWIN J. DE BEER
OSKAR P. WINTERSTEINER
DAVID B. STEINMAN

Finance Committee

ROBERT F. LIGHT, *Chairman*
GORDON Y. BILLARD
HARDEN F. TAYLOR

PROGRAM OF THE EVENING

After the Business Meeting, the following program was given:
The President's Address. M. L. Crossley, Retiring President, New York Academy of Sciences.
Triumphs in Dyes. M. L. Crossley.
Romance of Bridges. D. B. Steinman, Consulting Engineer, New York, N. Y.

THE PRESIDENT'S ADDRESS

By M. L. CROSSLEY*

In these days of world anxiety, unrest and uncertainty as to the future, I feel that I have a special opportunity, as Retiring President of the Academy, to lay emphasis on the stability and steadfast purpose with which this institution has pursued its ideals and aims for more than a century, especially in view of the close-up picture which I have had of its character and work during the past year.

The Academy stands forth as embodying America's great vitalizing traditions of responsibility, accomplishment, and independence, and the paramount worth and dignity of the individual, as exemplified by our scientists in their search for truth. The history of science as a whole, like that of our country, is the record of a select group of men and women who have the courage to accept the challenge of the unknown with fearlessness and an insatiable spirit of inquiry; who have vision to pierce the veil of doubt and uncertainty and convert hopes into realities. Because the Academy has accepted these principles, it has developed high standards of endeavor and a resourcefulness in accomplishing its aims, which have enabled it to overcome formidable odds and to solve many difficulties in attaining its purpose of genuine usefulness to Science.

One hundred and thirty-four years is a long time to survey in the life of an institution. For the most part, the Academy has grown slowly, acquiring a solid foundation on which to build. During the past fifteen years, however, there has been a noteworthy change in the development of the Academy due to the expansion of its activities and the acceleration of its growth in membership and publication. The active support of the membership and the devotion of the staff has enabled the Academy to excel many other institutions in rendering indispensable service to science through the promotion of its series of conferences, and the regular Sectional Meetings, together with the important monographs and other publications resulting therefrom.

The Academy is a science center furnishing an environment that is appealing to all who visit the building and attend the meetings. The informal atmosphere of the Academy encourages compatibility on the part of the participants and creates a warmth of good fellowship, thus stimulating the exchange of ideas and closer understanding. All of these factors have caused the Academy to be recognized as of fundamental importance throughout the scientific world.

The Academy will continue to remain strong so long as we, as Americans and scientists, uphold its purpose and methods of accomplishment through sincere cooperation and solidarity, with a determination to thwart any effort to weaken its fitness to survive. Solidarity in action is attained only by oneness of purpose.

The reports of the Officers, presented this evening, carry a two-fold message at this particular time: the one, of accomplishment during this past year; the other, of the needs and responsibilities of the future.

The outstanding achievements of the past year were notable. The task of moving and settling into the new building, thus giving the Academy a dignified setting and dimensions in keeping with its standards, called for the utmost endeavor on the part of those concerned and more than tested the full capacity of the limited resources of the Building Fund. The strenuous effort to bring the publication program up-to-date resulted in a substantial progress, with twelve important monographs published. The growth of the activities, membership, and sales of publications continued. These all brought a decisive period of successful change, adjustment, and growth. A close acquaintance with the workings of the Academy is a striking object lesson in the accomplishment of much with very slender means and justifies its reputation for efficiency.

* Retiring President, New York Academy of Sciences and former Director of Research, Calco Chemical Co.

The future holds much of work to be done in obtaining further support for our financial needs. We must realize the desirability of preserving the high standards of the scientific activities as well as the independence the Academy has gained through having its own building. Naturally, these strides forward bring added responsibilities, since the Academy must carry the mortgage and maintain its home successfully. The conferences not only must continue on the same high plane of quality of scientific subjects pertinent to present-day research but must bring assurance of prompt publication to the authors. The Academy needs an adequate fund for these and many other purposes. It needs a larger auditorium for the regular meetings and the conferences. Adequate funds must be obtained to enable the Academy to realize fully its aims and obligations. Money could find no greater usefulness for the service of mankind than in preparing this scientific center to serve science and technology with the greatest possible efficiency and widest scope. The donation of a lecture hall could be a memorial of ever increasing importance and value.

Every year is crucial for the Academy, because, having only a slim endowment, it must nevertheless face the problem of continually recurring expenses. These are directly met by the annual income from dues, sales of the publications, and whatever grants may be obtained in aid of the publication program. There are no reserve funds.

Yet the Academy carries on unflinchingly, while its services are given without stint and in spite of its problems. No discouragement should ever cause it to reverse the progressive program and the upward trend of the last fifteen years. It should be borne in mind that fifteen years ago the Academy had only a few hundred members and slightly more than six thousand dollars in annual income. With determination and insight, it has reached the significant results as reported here tonight. The future, therefore, should hold no qualms for us, for, with close cooperation, constructive suggestions, and greater assistance from the Membership and friends of the Academy who wish it well, the future years of the Academy will continue to be fruitful.

An institution is what those who serve it make it. The success of the Academy is due to the dynamic, inspiring leadership of its Executive Director, Eunice Thomas Miner; to her loyal devoted associates who serve with pride and distinction; to the proficiency and industry of its Editor, Doctor Roy Waldo Miner, and to the high caliber of the men and women serving it on the Council and the several committees. The Executive Director is often both the rudder which keeps the ship on its course and the force which moves it on towards its charted goal.

In retiring as president, I wish to express my sincere gratitude for the help given me by all my associates on the Council, and particularly do I pay tribute to the Executive Director for her part in making my task light and enjoyable.

TRIUMPHS IN DYES

By M. L. CROSSLEY*

The great variety of synthetic dyes and pigments available today makes it possible to have all the colors of the rainbow for the expression of beauty and the emphasis of the realities of life. All about us we see these colors used to produce harmonious and pleasing results. Color has become an important means of attracting attention and holding interest in advertising. In the arts and industries, it is used lavishly to enhance the beauty and attractiveness of products. From draperies to dishes, shoes to rouge, it

* Retiring President, New York Academy of Sciences, and former Director of Research, Calco Chemical Co.

helps to establish the environment for comfortable and pleasant living. The modern woman may select her wardrobe to include the range of hues needed to bring out her beauty and charm. She may not only look the part of a flower in Life's garden but may also radiate its fragrance, choosing her perfumes to suit her clothes and her personality—fragrance of the rose for her provocative pink morning frock, lilac for a purple velvet suit, orange blossoms to bring out the fullness of her beauty in an orange colored smock, lily-of-the-valley to heighten her attractive grace in a white satin gown and trailing arbutus for her sapphire blue gown.

The pageantry of color essential to the fullness of life enjoyed by many in this country today has resulted from a series of scientific and technological triumphs in dyes and related products which, when fitted together, give a mosaic of accomplishment of great importance. Dyes and pigments, capable of giving a wide variety of hues, drugs, and other intimately related products are now produced in abundance. New industries of vital importance to our national economy have been established. This industrial development has been accomplished in the United States during the past thirty-five years. It represents a great triumph for the American's will to accomplish and his capacity to harness the forces of science, technology, finance, and management into a team for successful achievement.

In 1915 when we woke up to the realization of our plight that we could not dye a yard of cloth, prepare a differentiating stain for determining the microorganisms causing disease, or have a drug to relieve a headache without obtaining the products from foreign manufacturers, we determined to cast off the economic shackles of European cartels, which controlled these products, and produce them ourselves. We had no specialized knowledge of the processes involved and no manufacturing experience. Much that was known abroad had to be rediscovered here the hard way. There were few organic chemists and they were mainly in the universities, devoting what time they had for research to the extension of the several studies they had been led into by the professors under whom they did their graduate work. Research in industry was very limited and employed but few chemists. There was but one university laboratory in this country interested in color and constitution and in providing graduate study in the fundamentals of the synthesis of compounds capable of giving color, and only occasionally did a student show any interest in doing graduate work in this field. Few followed up with research in color after completing the work for the doctorate. Of course, we had the scientific and patent literature, which contained much information but little knowledge. Isolated facts tossed into the sea of scientific and technological literature are as useless as sand and pebbles churned into a confused surf rolling in upon a desolate shore. Neither can release its potential power for effective results until organized and understood. The cement of experience is needed for building facts into useful knowledge.

The forceps of necessity delivered the infant dye and organic chemical industry in this country during World War I, and it was nourished by the milk of war economy fortified by the vitamin "protective tariff." Under no other conditions could it have been brought through the perils of competition with foreign controlled monopoly, whose agents in this country ladled out the gravy to buyers to insure that they would find justification for using their products. The "drug room" in the textile mill was a foreign oasis which was captured by the mill owners with difficulty, even when the plant could operate only by purchasing American manufactured products. The average mill owner became aware of the importance of dyes and related chemicals in his business only when he was forced to shut down for the lack of the product. One of the first to feel the blow was the big blanket factory at Mystic, Connecticut, which closed its doors on August 15, 1915.

At the outset, this infant industry recognized the importance of research in determining its chances for survival. To start, it had to deplete the universities and technical schools of their young chemists and engineers. These young men and women

learned by trial and error the best means of producing the dyes, drugs, and explosives needed immediately. In the years that followed, our universities and technical schools did a magnificent job in educating promising young men and women to become capable scientists and technologists in industry. These young people discovered that there is no well-defined boundary between pure and applied research.

By pure research, one usually means that undefiled by any practical aims. Too often, such research is conducted wholly to increase information in a specialized field, without any desire or obligation to try to understand its significance in relation to the body of existing knowledge. There is no unreconcilable conflict between original thinking and purposeful endeavor. Industrial research blends fundamental and applied science to achieve the desired results. An improvement in a manufacturing process to lower the cost of the product may require first a thorough study of the kinetics of the reaction involved. The industrial research man becomes inoculated with the virus of practicability without acquiring an immunity to creative thought.

The development of dyes and other coloring agents to meet the exacting demands of constantly improving standards induced by the highly competitive free enterprise system in our business economy has been a great triumph of which the country can be justly proud. Colors are available for producing a great variety of effects with clarity of tone, brilliance in hue, and considerable permanency. Dyes to produce relatively fast colors have made possible a greatly improved art of dyeing in which the old and the new textiles may be employed with maximum effectiveness in clothing and other manufactured products. From pink pajamas to strands of coral beads, quality is the aim. Even when a yellow is to be used as one component of a sepia brown, purity of tone is demanded and had. No less great has been the triumph of developing suitable coloring agents for the new synthetic fibers, plastics, and paints. The results are evident everywhere: in wearing apparel, household furnishings, magazines, and automobiles.

Color is a physiological sensation produced by a light stimulus from a material which is capable of withholding certain increments of light energy of definite quality. A dye or coloring agent, to impart color, must have a molecular structure providing the atomic groups needed for absorbing from the white light or sunlight that reaches the molecule, light of definite wave length. The residual light returned from the substance is the stimulus which produces the sensation of color, and the hue will depend upon the nature of this light stimulus. Molecular architecture is, then, an important consideration in the chemistry involved in the synthesis of dyes.

It is never possible, on a practical basis, to synthesize a dye to give each tone of a hue desired. The wide variety of hues required in the industry are obtained by blending the dyes which will give the desired results. This was accomplished by long and costly empirical dyeing procedures. The researches in fundamental physics conducted by industrial laboratories have made possible instruments and technics for making the blends quickly and with great precision. The "thumb prints" of each color can be made in a few seconds, and the mixture of dyes to give the desired result can be calculated from the known properties of the individual dyes when applied to the medium to be colored. The absorption curve characterizes the composition of light which induces the sensation of color, but it is not the color. One could express by curves the colors that make up a beautiful sunset or charming, lovely lady, but the results would not be exciting. They would not satisfy the human sense of color value in beauty.

Another triumph of the dye industry is to be seen in the progress made in the development of synthetic drugs and their use in medicine. Dyes and drugs are intimately related. Without the dye industry, this country could not have developed and produced the many valuable drugs now indispensable to modern medicine. The same

parent substances which, by certain chemical and technological treatment, give derivatives capable of producing all the colors of the rainbow, will also give, by other treatment, drugs and other important products. Benzene is the chemical ancestor of aniline, phenol, and many other industrial important intermediates. From aniline are derived dyes which give a wide variety of brilliant colors as well as blacks, which are as far away from color as only black can be. From the same intermediate, there are derived important drugs such as the sulfa drugs, compounds that accelerate the vulcanization of rubber, and other useful products in a variety of interlacing industries. From phenol, one line of research leads to the development of important drugs such as aspirin, another to dyes, another to resins which find their use as plastics and synthetic fibers in modern industry. The interdependence of the dye and other organic industries is also illustrated by the chemical descendants of naphthalene, or ordinary mothballs. One line of creative effort leads to the perfume of orange blossoms, another to dyes which give effects varying from black to brilliant scarlets, and another to insulating materials which make it possible for us to have steady electric lights in our homes. Still another gives products that extend the life of rubber in automobile tires.

Up to certain definite stages, the intermediates for drugs and dyes may be the same. The economic conditions that determine the success of one may depend upon the use for the other. The research to insure the continued progress of the dye industry also catalyzes thought and action in the development of new drugs and in the study of their potential possibilities in medicine. Products made for the treatment of textiles may become useful aids in combatting cancer. The study of drugs leads to research on the basic chemistry involved in health and disease. The physical laws and chemical reactions in the selective absorption of dyes by fibers provide ideas as to similar phenomena in living tissues. Often, the equipment designed for the study of dyes may serve for the investigation of the functions of the lungs, kidneys, and other organs of the animal body. The researches on dyes and drugs are indissolubly linked in symbiotic accord.

Raw materials and intermediates needed in the production of dyes have been employed to improve and extend the usefulness of products of widely different industries. The manufacture of gasoline has been greatly improved by the use of organic solvents for purification. The life and serviceability of automobile tires depend upon the use of antioxidants and other agents developed as intermediates for dyes. The great strides made in the electrical and communications industries could not have come about without a dye industry. Organic insulating material makes possible better and more efficient electrical service. Synthetic fibers such as nylon have evolved from industrial research to widen the scope of the usefulness of products made primarily for dyes. The physical and chemical research in dyes called for fundamental investigations which opened up new vistas of opportunity for accomplishment.

Of the many triumphs achieved in developing a dye industry in this country, perhaps the greatest of all is the stimulus it has given to scientific research and technological advancement. In a little over three decades, thousands of capable research chemists, physicists, biologists, and engineers have been educated and trained. The need for their services in industry has encouraged many of our most promising young men and women to elect research as a career. Their untrammeled minds and youthful vigor give them versatility and perspective, which, coupled with originality and imagination, fit them to play an important role in the advancement of science and technology. The horizon of science in this country has widened. The sun of hope has risen and the light of knowledge filters into dark recesses of ignorance and doubt, assuring a succession of scientific triumphs in the future.

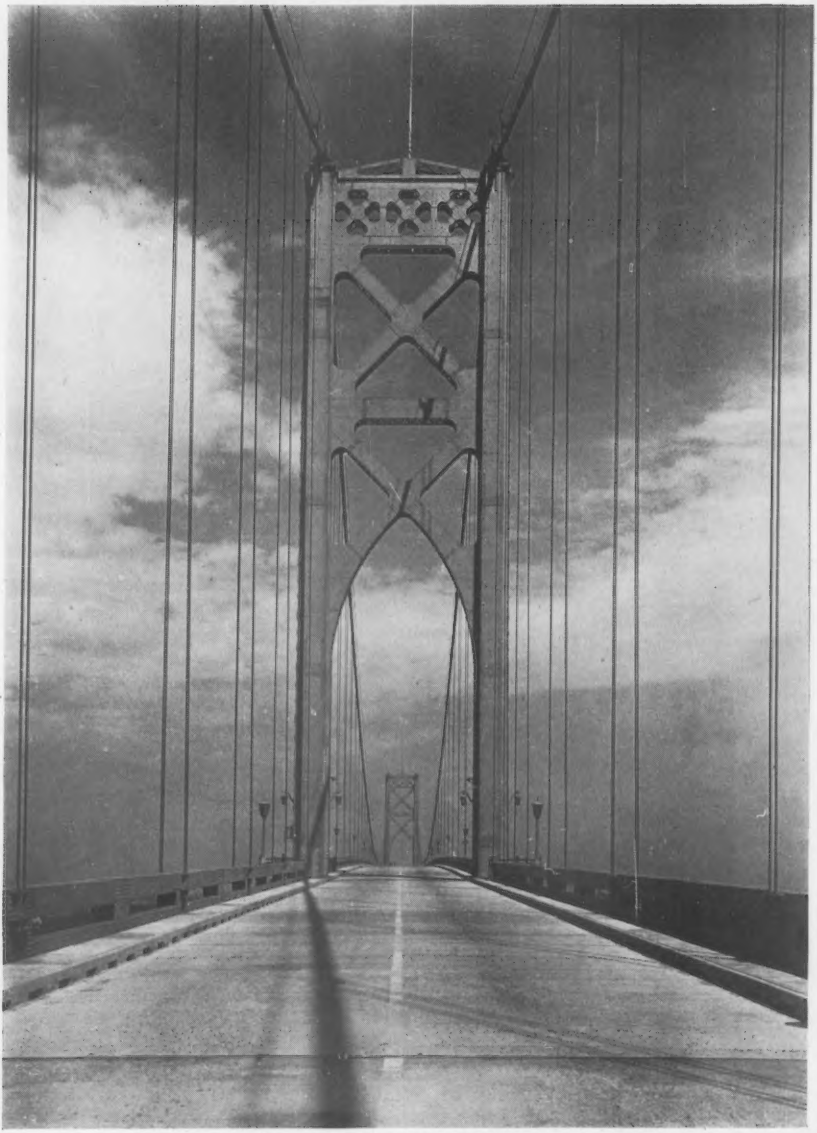

FIGURE 1. Mt. Hope Bridge, Rhode Island.

ROMANCE OF BRIDGES

By D. B. STEINMAN*

This paper is to be informal and non-technical. Its object is to give a glimpse of the drama, the romance, and the poetry of bridges. It will attempt to show that a bridge is something more than a thing of stresses and strains, stone and steel—that a bridge can be something exciting, inspiring and beautiful.

Back in 1889, the great Forth Bridge in Scotland was completed. It had a span length of seventeen hundred feet, and, for a long time, it was the longest span in the world. Then, at the beginning of this century, the Canadians undertook to build a longer bridge—the Quebec Bridge, over the St. Lawrence River, with a span a hundred feet longer than the Firth of Forth Bridge.

On August 29, 1907, the bridge was out to mid-span when, suddenly, one of the bottom chord members buckled, and the whole bridge came crashing down, a tangled mass of wreckage, with eighty-two lives lost in the disaster. There followed years of investigation, adding new knowledge to the science of bridge engineering.

Following this, a new design for the bridge was prepared, a more rigid design with straight outlines, a new type of truss, and two and a half times as much steel to carry the same load. In order to minimize the erection stresses, a different method of raising the suspended span was used. It was floated out to midstream on barges, after which it was to be hoisted by jacks to the height of a hundred and fifty feet above the St. Lawrence River. This was in 1916. After the span had been jacked up about six feet, however, something slipped and the span came plunging down, with a loss of thirteen more lives.

The following year, another suspended span was prepared and floated out to the site. But this time a more rigid lifting mechanism was employed, with hydraulic jacks to raise the span stage by stage until, at the end of four days of jacking, ninety-six hours, the span had reached its full height above the river and the bridge was completed. And thus, at the price of two great catastrophes, the world's greatest span length was increased from seventeen hundred to eighteen hundred feet.

Ten years after the Quebec Bridge erection, we built a cantilever bridge at Carquinez Strait in California, about twenty-five miles north of San Francisco, the largest cantilever bridge in the United States, with two spans of eleven hundred feet. It was the first bridge ever designed to resist earthquake forces, with the earthquake stresses taken into account in the design and with giant hydraulic shock absorbers across all the expansion joints to take up any shock.

In erecting the Carquinez Strait Bridge, a new method of lifting the suspended span was devised. It was raised to the same height as the Quebec Bridge, a hundred and fifty feet, but took only thirty-five minutes. Ten thousand people lined the shores, drawn to the scene by the exciting anticipation of a possible catastrophe. Some of the spectators must have gone home a bit disappointed, but those of us whose hearts were in that project breathed a deep sigh of relief when the suspended span was in final position and connected to the cantilever arms.

Now I can pass on to another bridge, which is a grand old bridge—the Brooklyn Bridge, shown in FIGURE 2. I call this particular picture "Roebling's Dream." The drawing was made by Roebling and his assistants from his plans before the bridge was built, and it depicts the way Roebling envisioned the bridge. I tell the story in my book,* and I quote this excerpt:

> "In his heart and in his mind he saw the great bridge of his dreams—the magnificent pylons, enduring as the

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* "Builders of the Bridge," by D. B. Steinman. Harcourt, Brace. New York.

pyramids, founded on solid rock deep below the rushing tides; the powerful cables of steel sweeping downward and upward in the arc of nature's law, and the arching roadway carrying the multitudes over a span greater and more beautiful than the world had ever seen. He saw it clearly, as it was to be—a great work of art, the great engineering work of this continent and of the age.

"Time was to justify this prophecy, and posterity was to behold the magic and the power of the thing he had created. But he, who had dreamed and planned all this, was not to see the timeless towers, or the vast sweep of the mighty cables, or the rushing thousands crossing on the far flung span. He was not to see his bridge take form. He was not even to see the first stone laid. From ancient times the tradition has been passed down from generation to generation, 'The bridge demands a life.' In this case the bridge demanded the life of its creator. At the end of the race, with the goal in sight, fate exacted its toll, a toll doubly cruel by its timing."

On May 24, 1883, the great work was finished. It had cost over twenty lives and had taken thirteen years to build. The two master builders had paid their price, one with his life, the other with a crippled body. The father had dreamed the bridge and the son, with gallant fighting spirit, had carried that dream to fulfillment. No inspired builder of a medieval cathedral brought to his work a greater singleness of purpose, a more selfless devotion, than the two Roeblings lavished on their master bridge. The best in their characters went into its building. Of granite and steel and dreams, the bridge was built.

Recently, I was engaged to rebuild and modernize the suspended structure—the roadways and the trusses—of the Brooklyn Bridge, increasing its capacity from two lanes to six lanes of modern highway traffic.

FIGURE 2. Brooklyn Bridge, "Roebling's Dream."

This engineering engagement gave me a particular thrill of satisfaction: the world-famous structure that had inspired me in my youth had come back to me at the height of my career. The crowning work of the pioneer master-builders had been entrusted to my professional skill and care for lengthening of its life and enlargement of its usefulness. It was another dream come true.

When people expressed concern about the proposed modernization of the beautiful old span, I was glad to reassure them that the appearance of the bridge would not be changed. To me, Brooklyn Bridge is sacred.

I pass on now to another bridge, the Florianopolis Bridge in Brazil (FIGURE 3). This is the largest bridge in South America and the longest eyebar suspension span in the world. This bridge was built in the southern part of Brazil for the Province of

Santa Catharina, which has its capital on an island out in the Atlantic Ocean. The bridge was built for the purpose of carrying a highway, a railroad and an aqueduct to the island capital. It was the life dream of the governor of the province.

This job was awarded to us through an international competition. After we got the award for the bridge, I conceived a new form of suspension span, in which the middle half of the cable is utilized as the top chord of the stiffening truss. This, incidentally, gives a desired profile having a maximum depth at the quarter points with greater economy and rigidity than conventional practice. In fact, this design, compared with the previous conventional design, was four times as rigid and required only two-thirds as much steel.

FIGURE 3. Florianopolis Bridge, Brazil.

At the time of the Florianopolis and Sydney Harbour Bridge designs, I noted in published discussions the unusual degree of rigidity we had secured in our suspension bridge designs. Some of the older engineers said, "That is all wrong; the idea is to make suspension bridges more flexible." That school of thought reached its climax in the ill-fated Tacoma Narrows Bridge, a suspension span of twenty-eight hundred feet, completed and dedicated July 1, 1940.

From the start, the Tacoma bridge was found to have peculiar up and down heaving oscillations. Instead of frightening automobilists away, this phenomenon caused traffic over the bridge to treble. Motorists came from hundreds of miles around to enjoy the thrill of riding over what amounted to a bouncing, galloping, roller coaster. The bridge proved very profitable, and nothing effective was done to stop the heaving oscillations.

Four months later, on the morning of November 7, 1940, after the up and down oscillatory motion had persisted for three hours, it suddenly changed to a twisting motion, and that motion was amplified until one side of the bridge went twenty-eight feet higher than the other, and then down to about twenty-eight feet lower. Finally, after half an hour of that motion, the bridge broke, with a six hundred foot section dropping out and turning upside down before it fell into the water, two hundred feet below—the end of a six million dollar bridge, the end of a dream. Men had put their hopes and their dreams into that span, and there it lay in the water, a crumpled wreck.

Years of investigation started. In our studies of the subject, even before the Tacoma Bridge failure, we had evolved methods of curing aerodynamic instability that were effective. One method of preventing the oscillations was the use of inclined stays running up to selected points of the cables. Another method we used successfully on two bridges was the installation of rigid diagonal ties at the middle of the span, joining the stiffening girders and the cables. This method was copied on the Tacoma Narrows Bridge, but the ties were made of wire rope

instead of rigid angle members, with the result that when one of those wire ropes snapped, the bridge was wrecked by the wind.

There is another very simple and economical method, using transverse diagonal stays, that absolutely prevents torsional oscillation. In addition, we have found, through wind tunnel tests, sections for bridges that will completely eliminate aerodynamic instability, because they will not have the amplifying forces necessary to produce these oscillations. There are two ways of solving the aerodynamic problem. One is to prevent the cause and the other is to try to cure the effect. There are from ten to twelve bridges in this country that are sick in this respect, and I have had the doctoring of several of them.

Another kind of wind trouble came along in 1944, when the Chester Bridge over the Mississippi River was blown down. I had pointed out three years previously that engineers have been neglecting an important force acting on bridges, *viz.* the uplift produced by the horizontal force of the wind. There is no mention of that lift force in any bridge design specification throughout the world. My further studies and tests have revealed that the lift due to the wind can amount to five or six times the horizontal wind force. It can be shown that the actual overturning effect due to wind can be as much as two hundred and seventy-two times the amount presently specified in bridge specifications. Bridge specifications for wind forces have all been inadequate. This is all new knowledge, obtained within the last few years.

Now I want to pass on to a different phase of the subject: *Beauty in Bridges*. God made the world beautiful, but man, without thinking, has marred it with structures of ugliness. For example, looking out from the Canadian side we get a beautiful view of Niagara Falls. On one side are all the magnificent splendor and glory of the Falls. On the other side, however, we see chimneys and smoke stacks and factories and power houses and office buildings, with advertising signs on them and much else of ugliness. I say that we engineers have no right to produce ugly structures; we have no right to mar the beauty of the landscape. People have to live with the structures we build, and they must be made pleasing and appealing to the eye.

When I was a student in bridge design at college, I never heard the word "beauty" mentioned. We were told about stresses and strains, indeterminate structures, secondary stresses, details, and specifications, but not a whisper of the fact that bridges can be made beautiful as well as strong. Something in my heart told me that bridges can be beautiful, however, and I went around studying bridges to see why some were ugly, commonplace, and depressing, while others were beautiful and inspiring. I discussed it with other engineers and talked about it with officials of the American Institute of Steel Construction, and, in 1928, they established an annual award for beautiful bridges, to let the public know that bridges can be beautiful.

In 1929, we completed the Mount Hope Bridge over Narragansett Bay (FIGURE 1), a "bridge to take the island out of Rhode Island," and with the encouragement of the financiers we did everything possible, without adding to the cost, to produce a beautiful structure, with the result that it received the highest A.I.S.C. award, in 1929.

We developed the lofty Gothic portal sixty feet high above the roadway, thus eliminating the effect of crowding. The vertical legs of the towers harmonize with the lines of the suspenders and the curved lines of the portal harmonize with the curved lines of the cables in "point and counter-point," to produce a harmonious composition working up to smaller details at the top. Many people have declared that the Mount Hope Bridge is to them the most beautiful bridge in the world, and I must confess that, every time I see it, I experience the thrill an artist feels when his conception has taken form in a thing of enduring beauty.

Bridges can be made beautiful without

sacrificing economy. The official design for the Mount Hope Bridge, made by a state commission, proposed a cantilever bridge estimated to cost $6,000,000. The legislature would not appropriate that sum, so private bankers undertook financing of the project. They came to me and inquired whether the bridge could be built for $4,000,000. I told them we could built it for $3,000,000 and we did build it for $2,500,000.

In the hurricane of 1938, when New England presented a scene of devastation, when everything around the bridge site was a tragedy of destruction, this bridge stood up undamaged, requiring not one cent of repairs. It stood up in defiance of the worst storm on record, proving that we can make bridges beautiful, enduring, and efficient.

Two years later, we completed the Waldo-Hancock Bridge (FIGURE 4), over the Penobscot River in the State of Maine. The appropriation for the construction of this bridge was $1,200,000. We built the bridge for $800,000, used the balance to build another bridge, and still had money left over. This bridge also received the beauty prize.

Here is something new in line and form. Instead of using curved lines we produced an effect of beauty with straight lines by spacing, arrangement, and proportions, emphasizing the horizontals and verticals. The entire structure is designed to give alternation, repetition, harmony, and rhythm—the elements of music. A bridge can be just as beautiful as a poem or a musical composition and, at the same time, retain economy and efficiency of design.

In Portland, Oregon, the City of Roses, the St. Johns Bridge (FIGURE 5), has a beautiful scenic setting. On one side are forest clad hills and on the other is a panorama of river, city, and valley, with snow-clad mountain peaks glistening distantly in the sunlight. With such a beautiful setting near the famous scenic Columbia River Highway, we were inspired to build a beautiful public structure. In the towers, we used vertical lines for direct load and inclined legs for bracing, and further developed the pointed arch portal, because the dominant theme in a suspension bridge is that of curves meeting at a point. The portal openings in the towers frame beautiful pictures of green trees, blue sky, and white clouds. The spires at the tops of the 400-foot high towers are not useless decoration, but serve a useful function to carry the thirty-two inch high aviation beacon lights. This whole structure has been called a symphony in stone and steel.

Starting with the Mount Hope Bridge, I introduced color in bridges. We had grown tired of seeing bridges painted black and battleship gray, and decided to get away from these sad, somber, cold colors and into something warm and colorful, to harmonize with and be a part of the landscape. In the case of the St. Johns Bridge we became bolder and proposed a verde green color for the bridge. In describing it to newspaper reporters I happened to use the phrase "blending or harmonizing with the landscape," and at once the newspapers began to get letters from the public, stating that the bridge would be a menace to aircraft because of low visibility. The county officials thereupon sought the advice of aviation authorities and government officials, who replied that for maximum visibility the bridge should be painted *yellow with black stripes*! The county commissioners had asked for advice and they had gotten it but did not know what to do with it. So, after waiting a few months until the date of March 17th, St. Patrick's Day, they boldly announced that the bridge was going to be painted green, the original color proposed.

Another feature we had introduced in bridges was night illumination. Starting with the Mount Hope Bridge, we pinpointed the cables with lights, giving them the appearance of beads of gold. And the highway also was pin-pointed with blue lights, the whole producing a symphony of color. We turned on the lights on the night of the Edison Memorial, Light's Golden Jubilee, as a tribute from one field of progress and development to another.

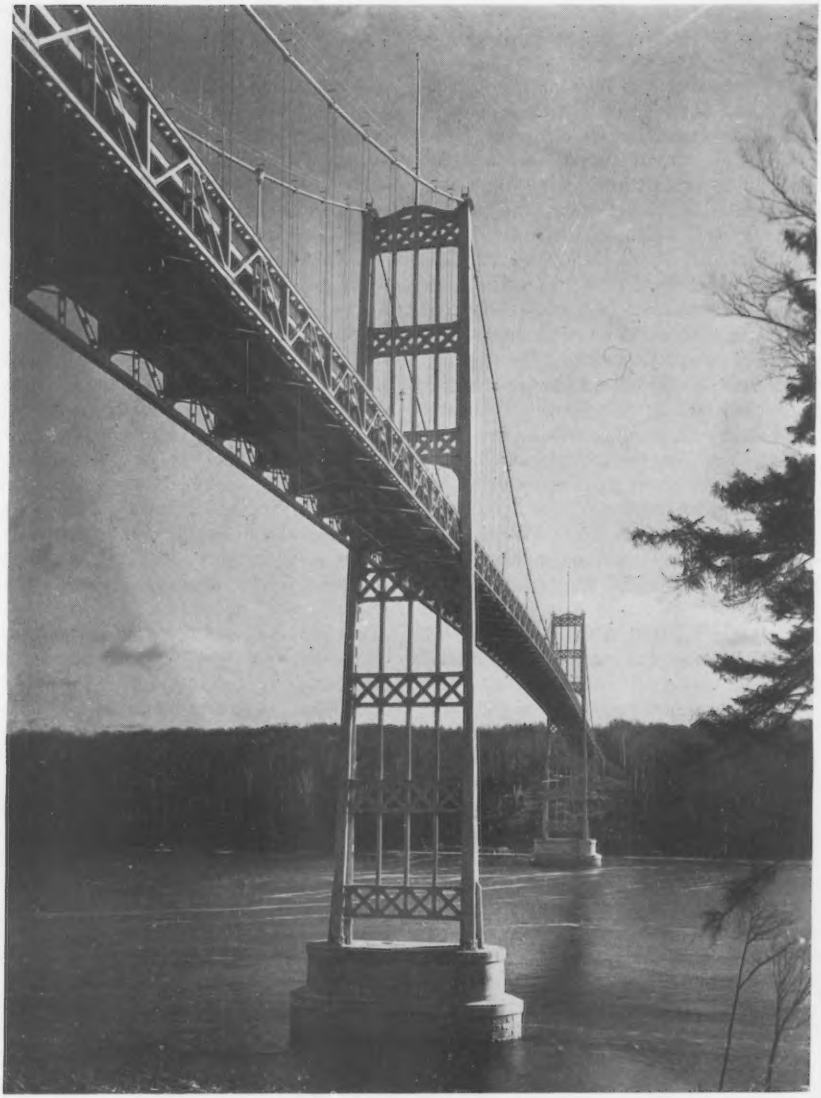

FIGURE 4. Waldo-Hancock Bridge, Maine.

In the case of the St. Johns Bridge, I proposed a radiant colorful system of flood-lighting to bring out the beauty of the bridge at night. The estimated cost was about $30,000. The county officials, being economically minded, vetoed the proposal even though I had saved them over $500,000 on the cost of the bridge. All they would allow for the extra illumination was $500. We did the best we could with this small

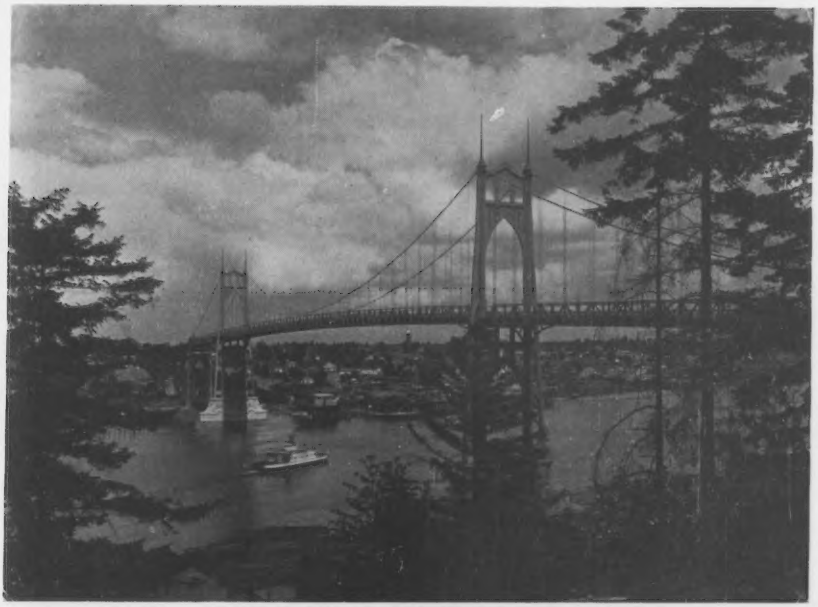

FIGURE 5. St. Johns Bridge, Portland, Oregon.

FIGURE 6. St. Johns Bridge (night view).

sum and placed flood lights at the towers producing a certain mystic effect of beauty (FIGURE 6). It was called "a poem stretched across the river."

I call FIGURE 7, "architecture in structural steel." Everything shown in it is structural steel; nothing is added for ornamentation or decoration. Every pound of metal does its

work; not a pound of steel is wasted. Everything is thought out in the development of the design for maximum effect of beauty, for interest, for contrast, for relief, and for lights, shades, and shadows, all to make a harmonious composition. That is the something-plus that the bridge engineer can put into his work.

Early in the 1930's the Hartford Bridge Commission retained us to make a design

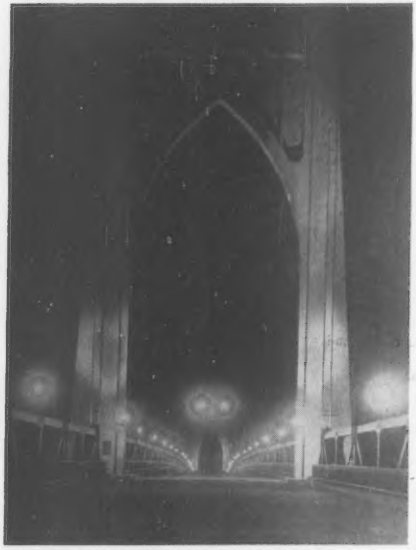

FIGURE 7. "Architecture in Structural Steel" (St. Johns Bridge).

for a suspension bridge over the Connecticut River at Hartford. They had seen our designs for other bridges, they had seen the actual structures, and they wanted something of the same character and type, only more so. We did our utmost and developed a design, carrying the pointed arch theme to a climax. When a design is in the development stage, we are not satisfied with making the usual engineering drawings. We make perspective drawings, viewed from different angles and for different studies. We made a total of over ninety-five different artistic rendered drawings for this one suspension bridge design.

The officials were enthusiastic and they adopted our design, telling us to proceed with preparation of the engineering drawings. After we had made considerable progress and these drawings had been published in the daily press, some people wrote to the newspapers saying they objected to anything that looked ecclesiastical or pontifical in the colonial setting of Hartford. The bridge officials came bashfully to New York to ask me to make the designs *colonial* instead of *gothic*. We do not call it "gothic," it is just an appropriate form of development. However, we proceeded to change the form of the arches into what is called "colonial." The estimated cost of the suspension bridge was about $5,000,000, with a main span of eight hundred feet.

The money, however, was not forthcoming because of the depression, and then, as years passed and navigation conditions changed, it was found that a much smaller span would suffice. A new design was accordingly made by us and was built (FIGURE 8). It is known as the Charter Oak Bridge. This bridge is a continuous girder of three spans. The middle span is three hundred feet, the longest plate girder span in America. In addition, the approach spans are also made continuous, despite the fact that they are on a horizontal curve, giving rise to a very interesting design problem, continuous girders, horizontally curved. Recently, the American Institute of Steel Construction gave the highest artistic award to this bridge.

I would like to go now to the subject of arch bridges. One of my earliest jobs was the Hell Gate Arch Bridge. When the people from Australia saw this bridge, they decided to build a structure of the same form over Sydney Harbour, a span of 1,650 feet. The Sydney Harbour Bridge was finally completed and dedicated in 1932. It was the ambition of the Australians to have the longest span arch bridge in the world, but another bridge, on this side of the world, over the Kill van Kull at Bayonne, New Jersey, started five years later, was completed four months earlier, and was made

twenty-five *inches* longer. The famous Kill van Kull Bridge, built by the Port of New York Authority, is the longest arch span in the world, 1,652 feet, one inch, and is also a prize winner in the annual bridge awards. It is a half-through arch span.

Many of us feel that the arch is an ideal form of structure, expressing something dynamic and conveying the feeling of a powerful thrust, carried down from the loading to the abutment. In order to complete this picture, however, the roadway line and loading should be at the top of the arch, giving the structure the effect of bearing a burden. That is why the ideal form of design is a deck arch. The Henry Hudson Bridge at New York City over the Harlem River (FIGURE 9), at the scenic entrance to New York, is an outstanding example of the deck arch bridge.

The Henry Hudson Bridge has meant a great deal to me, because it was the subject of my student thesis for degree of Civil Engineer at Columbia University back in 1908 and 1909. Then, twenty-five years later, that project became a real job and was handed to me for my firm, the same type of bridge and in the same location, with a span of 800 feet. It was, at that time, the longest hingeless steel arch span in the world.

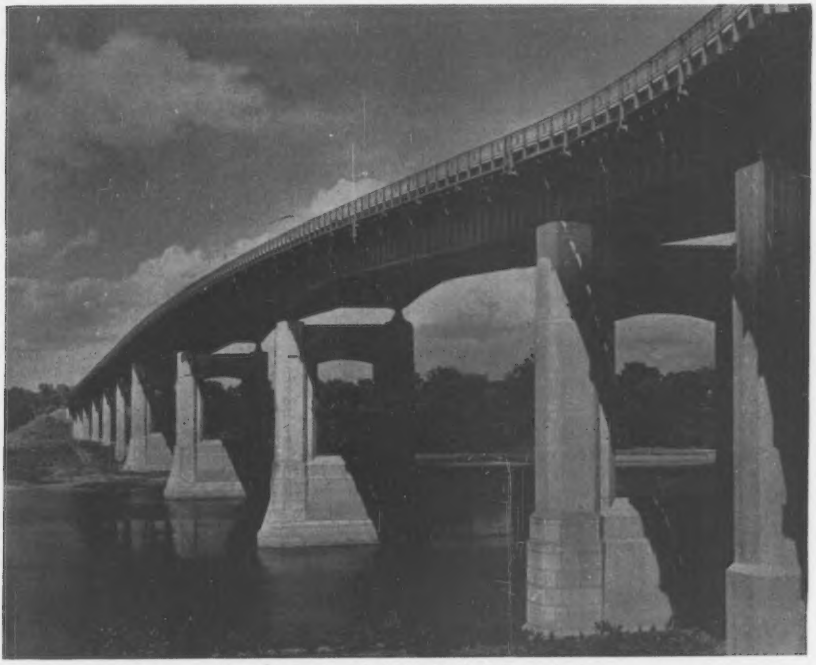

FIGURE 8. Charter Oak Bridge, Hartford, Connecticut.

In our studies for the Henry Hudson Bridge, we proposed a toll bridge twice as wide, but, since it was financed during the depression, the bankers were timid and they made us reduce the width of the bridge one-half. We made provisions, however, for a future upper deck, and one month after the bridge was opened to traffic I received instructions to proceed with the upper deck. The bridge now carries 18,000,000 cars a year.

In 1938, we completed the Thousand Islands Bridge, over the St. Lawrence River, an international bridge, eight and a half miles across. The project included five different bridges, plus viaducts and approaches, and all we had to build it with was $2,200,000. So, we used our utmost resourcefulness to develop the most economical design and made a thorough study of the site. For example, on the crossing between two of the islands on the Canadian rift, we built "the biggest-little bridge," a span of only ninety feet, which is an international bridge, one end in Canada and the other end in the United States. A thin bronze dividing line in the middle of the span marks the international boundary. At this point, President Franklin D. Roosevelt and Prime Minister Mackenzie King cut the ribbon and thereby celebrated a hundred years of peace and good will between the two nations.

FIGURE 9. Henry Hudson Bridge, New York.

side, we found a small rock island right in the middle of the channel, so the logical thing was to make this a two-span continuous truss, using the rock island for the center support. At the next channel, between two islands, we found natural sloping rock at each bank. The logical solution was an arch bridge, so at this point on the rock we built a triple function pier to serve three purposes, including the anchorage for a suspension bridge with a seven hundred and fifty-foot span.

On the American side, there was another suspension bridge, of eight-hundred foot span, and, nearby, over what is called the

The gem of the entire Thousand Islands crossing is an arch bridge (FIGURE 10) over what is called "Lost Channel," honored in the artistic bridge awards of the Steel Institute. The pathetic part of it is this, that the millions of tourists who cross the bridge never see it. One has to go below in a motor boat to see the beauty of the span. Even if the multitudes cannot see the structure we have built, it is our duty nevertheless to make the work beautiful.

Between Indiana and Illinois is a little bridge over the Wabash River, only a 350-foot span. Using a rolled beam for the stiffening girder, a very economical design

was achieved. Conditions were not suitable for suspension bridge anchorages, so a self-anchored suspension bridge design was adopted. The ends of the cables were secured to the ends of the span to make the bridge take up the thrust. This bridge is a little gem of beauty and is technically interesting as well. Students in the engineering schools in neighboring states make pilgrimages to this location to study the design and construction of the bridge.

Now for a glimpse of some of the new things that are being done in suspension bridges, perhaps a glimpse into the construction of the future.

The Sky Ride at the Chicago Exposition in 1933–34, with a span of 1850 feet, had the same span length as the $20,000,000 Detroit Ambassador Bridge. Oddly enough, it carried an equal loading in tonnage or passengers per day, but instead of costing $20,000,000, it cost only $1,000,000. The Sky Ride was designed and built in six months, and carried a string of ten suspended cars weighing twelve tons each with thirty-six passengers in each car. In the two seasons of the Exposition, 4,500,000 customers were carried without a single accident, and, in the same period of just a few months, the original $1,000,000 investment was amortized. The novel feature, however, is the fact that no stiffening truss was necessary. We used diagonal stays to produce a stiffening system, so that the load line was maintained straight. With that form of design, there is no problem of aerodynamic instability.

Architects sometimes think of steel only as an ugly skeleton to be covered, as it is in buildings. Therefore, when they have to use steel, they try to hide it and conceal it. They naturally go to masonry towers, concrete, and granite. It is the natural thing for them to do, and that is why bridge engineers have had to do pioneering in artistic design in steel.

When the George Washington Bridge was completed, the addition of the masonry facing was deferred for financial reasons. The steel skeleton was not intended to be the permanent facade of the tower structures. When we saw the steel skeleton, we began to propose and urge that the encasement be omitted. The steel is the true carrying element, the element of strength and power, and it should produce the form of the structure. Anything else would be deception. The George Washington Bridge towers display a powerful effective beauty obtained accidentally and without conscious planning.

FIGURE 10. Thousand Islands Bridge over the St. Lawrence Rrver.

For twenty-five years, I have been working on what is to be the greatest and most beautiful span in all the world, a monumental suspension bridge. It is my dream bridge. We are presently planning this span for the proposed suspension bridge across the Narrows at New York (FIGURE 11), a span of 4,620 feet. It will solve much of the problem of traffic congestion in the

metropolitan area. Parkways, bridges, tunnels, *etc.*, converge and focus upon this crossing and the bridge is the one missing gap.

Our designs for this bridge were studied as far back as 1926, twenty-five years ago. The idea at that time was to develop a skyscraper tower to carry out the vertical gothic style in steel, and to express the qualities of steel, its beauty, its power, its grace. Today we use the simpler functional design shown in FIGURE 11.

FIGURE 11. Drawing of the proposed Narrows Bridge, New York.

The clear span from shore to shore will be 4,620 feet, more than 1,000 feet longer than the George Washington Bridge span. The roadway will be 237 feet above high water, 100 feet higher than the great suspension bridges over the East River. The towers will be 800 feet high, exceeding the height of the Woolworth Building. This will be the world's longest span and will represent the highest achievement of engineering progress.

The Narrows Bridge will be the world's proudest structure. Spanning the gateway to America, it will be a feature of fascination and inspiration to those who approach our shores. The majestic proportions and inspiring beauty of the great span will make it the outstanding symbol of our civilization. It will be a portal of hope and courage, typifying the spirit of America—our dreams, our faith, our striving, our fulfillment.

In all of this I have been trying to emphasize one continuous theme. The great pioneer builders who preceded us dreamed their dreams and wrought their dreams, giving health, strength, and even life itself as the price of achievement.

We are tackling even greater tasks. Whatever we may accomplish will, in turn, be eclipsed by those who follow us. In all of this, however, there is one outstanding thought I want to leave with you. It is summarized in one word, "consecration." By that I mean everything that goes into the feeling that our work will live after us, that we are building not for ourselves but for posterity. Beyond the steel and the stone, the timber and the concrete, there is one priceless ingredient, and that is the spirit of consecration. It includes vision, devotion, inspiration, and integrity. It is all beautifully summarized in the words of John Ruskin:

> "Therefore, when we build, let us think that we build forever. Let it not be for present delight nor for present use alone. Let it be such work as our descendants will thank us for and let us think, as we lay stone upon stone, that a time is to come when those stones will be held sacred because our hands have touched them and that men will say, as they look upon the labor and wrought substance of them, 'See, this our fathers did for us.'"

ABSTRACTS OF PRIZE-WINNING PAPERS

A THEOREM IN ELECTRO MAGNETICS, WITH USEFUL APPLICATIONS TO COMPUTING DEVICES

By DONALD LINCOLN HERR*

Awarded an A. Cressy Morrison Prize, 1950

This work concerns the formulation of the basic theory, design principles, and manufacturing processes of a whole new family of universal-frequency, high-precision, electromagnetic induction devices for use as computing elements in modern fire-control and analogue-computer systems. Basically these new devices are of two distinct types. In one type, the output voltage may be made to be almost any arbitrary function of input shaft angle-of-rotation; in the other type, the output shaft torque may be made almost any arbitrary function of input angle of shaft rotation. It is now possible to build analogue computers utilizing these devices for performing all of the basic mathematical operations of addition, subtraction, multiplication, and division, and non-linear functions. When used in conjunction with feedback amplifiers and servomechanisms, it therefore becomes possible to build a new kind of differential analyzer for the solution of both linear and non-linear differential equations; a new kind of high-degree electrical algebraic-equation solvers; and specialized analogue computers for the design of feedback amplifiers, servomechanisms, automatic control systems, and passive and active linear electrical, mechanical, and hydraulic networks.

Historically, this contribution is seen in retrospect to represent a synthesis of Fourier's theorem (concerning the representation of rational functions arising in engineering and science by an infinite set of harmonics each adjustable in amplitude and phase); the Schwartz-Christoffel transformation for potential and flow distributions in irregularly shaped, but periodic, geometric arrays; and the transfer characteristics of double, periodic, distributed conductor arrays. Each of these separate elements may have been well understood for many years, but the work reported upon in this paper represents the apparently novel combination leading for the first time, by virtue of its generalization and comprehensiveness, to the new families of voltage and torque electromagnetic computing devices. One of the devices arising from the initial phase of the work is now in successful mass-production in quantities of thousands. Many others may be expected to follow.

* Member of the staff of the Hughes Aircraft Company, Culver City, California; member of the Advisory Board of the Research and Development Laboratories of that company.

AN EXPERIMENTAL ANALYSIS OF MORPHOGENESIS IN *STENTOR COERULEUS*

By PAUL B. WEISZ*

Awarded an A. Cressy Morrison Prize, 1950

The explicit morphology of a ciliate protozoan is preeminently an expression of surface potentialities. Distinctive body shape, and differentiated organelles forming the diagnostic features of the organism, are maintained by the ectoplasm, which alone possesses the necessary properties of rigidity and plasticity. In searching for factors operative in ciliate morphogenesis, the roles of all three major subdivisions of the cell-like body must be considered; the nuclear apparatus, known to exercise fundamental initiating and controlling functions through its micronuclear or macronuclear components; the surface ectoplasm, site of final morphological expression, which contains local "organizers" determining the specific course of the emergent morphology; and the endoplasm, potentially or actually flowing, which may have the triple role of setting the metabolic stage for a specific morphogenetic occurrence, of providing the building blocks and the energy for this occurrence, and of acting as carrier for chemical messages between the nuclear apparatus and the surface.

* Department of Biology, Brown University, Providence, Rhode Island.

The morphogenetic repertoire of *Stentor coeruleus* Ehrbg. consists largely of three events, all of which involve fundamental changes in all parts of the body, *i.e.*, regeneration, physiological reorganization, and vegetative division. The aim of the present study has been to analyze these processes comprehensively by experimental means.

Regeneration experiments, carried out on *Stentor coeruleus*, show that adoral differentiation and contractile vacuole formation always occur at a free anterior terminal of the left boundary stripe of the ramifying zone, pedal differentiation always at a free posterior terminal of this stripe. Every point along the stripe is found capable of mediating either oral or pedal differentiation. An inherent polarity of the stripe is demonstrated experimentally. If the stripe is excised entirely, another ectoplasmic stripe may take over its specific functions, and normal, but delayed, regeneration may occur. It is concluded that a prime morphogenetic entity in regeneration is the kinety contained within the left boundary stripe.

Experiments are performed on different stages of fission and reorganization. Adoral zone, anarchic field, or both are excised. Four categories of results are obtained, characterized by the degree to which reorganizational processes continue and by specific morphogenetic events taking place later. Analysis indicates: that the formation of a fission line, fairly late during vegetative division, is presumably a causal consequence of mitosis; that the adoral zone probably exercises a contractive stimulus on the macronucleus, and that the anarchic field counteracts this stimulation if the adoral zone is not present; and that these and other interrelationships account satisfactorily for the timing of the various phases of fission and reorganization.

Experiments and correlative observations lead to the formulation of a comprehensive hypothesis which links together the different aspects of the morphogenetic repertoire of *Stentor* exemplified by regeneration, reorganization, and fission.

THE ACTION OF SALTS OF ZIRCONIUM AND OTHER METALS ON PLUTONIUM AND YTTRIUM DISTRIBUTION AND EXCRETION

By MARCIA R. WHITE AND JACK SCHUBERT*

Awarded Honorable Mention in the A. Cressy Morrison Prize Competition, 1950

Plutonium, the man-made element, used in the atomic bomb and a potential atomic fuel, is one of the most poisonous materials known to man. It may enter the body accidentally through cuts and bruises of the skin, or by being swallowed or inhaled. Once in the body the plutonium lodges in the bones, liver, and other susceptible organs where it continually emits alpha radiations. The constant bombardment from these is responsible for the toxic effects of the plutonium.

The only way to counteract the effects of plutonium is to remove as much as possible as rapidly as possible. In this paper are described methods for hastening the removal of plutonium and yttrium (another radioactive poison) from experimental animals. The substances used for treatment are salts of zirconium, titanium, and other innocuous metals. When zirconium, for example, is injected into rats soon after the injection of plutonium, there is a five-fold reduction in the amount of plutonium going to the bone and as much as a 50-fold increase in the amount excreted. Even when given *before* the plutonium enters the body, the zirconium is still effective. The mechanism of its action is probably as follows: When injected into the bloodstream the zirconium attracts all the plutonium in the blood, soaking it up like blotting paper, and carries it out of the body and away from susceptible tissues.

The complete theory given in this paper may stimulate further research leading to more effective methods for treating radioelement poisoning.

* Division of Biological and Medical Research, Argonne National Laboratory, Chicago, Illinois.

THE NEW YORK ACADEMY OF SCIENCES
announces
TWO PRIZE CONTESTS FOR 1951

The New York Academy of Sciences announces the following prize contests for the coming year.

I. THE A. CRESSY MORRISON PRIZE CONTEST

Two prizes of $200 each, to be known as the A. Cressy Morrison Prizes in Natural Science, will be awarded at the Annual Meeting, December, 1951, for the two most acceptable papers in a field of science covered by the Academy or an Affiliated Society.

II. THE GEORGE FREDERICK KUNZ PRIZE CONTEST

A prize of $200, offered in accordance with the bequest of the late Doctor George Frederick Kunz, to be known as the George Frederick Kunz Prize in Geology and Mineralogy, will be awarded at the Annual Meeting, December, 1951, for the most acceptable paper in the field of Geology and/or Mineralogy.

Conditions Governing These Prizes

(1) *Eligibility.* Authors and co-authors shall be members in good standing of The New York Academy of Sciences or one of its Affiliated Societies, but nonmembers may become eligible by joining one of these organizations before the closing date.

(2) *Date.* Papers are to be submitted on or prior to October 15, 1951, to the Executive Director of The New York Academy of Sciences, 2 East Sixty-third Street, New York 21, N. Y.

(3) *Papers.* All papers submitted must embody the results of original research not previously published. The manuscript shall be typewritten, in English, accompanied by all necessary photographs, drawings, diagrams and tables, and shall be ready for publication. Papers must be accompanied by a summary of the data presented and conclusions reached.

(4) *Awards.* The awards shall be made by the Council of The New York Academy of Sciences. The decision of the judges shall be final.

(5) *Publication.* The Academy shall have first option on the publication of all papers submitted, unless especially arranged for beforehand with the authors, but such publication is not binding on the Academy.

(6) Wherever and whenever published, the papers awarded the prizes shall be accompanied by the statement: "Awarded an A. Cressy Morrison Prize in Natural Science in 1951 by The New York Academy of Sciences," or, "Awarded a George Frederick Kunz Prize in Geology and Mineralogy in 1951 by The New York Academy of Sciences," as the case may be. If initial publication occurs in a form other than that to which the prize was awarded, a statement shall be included to the effect that an A. Cressy Morrison Prize in 1951 or a George Frederick Kunz Prize in 1951 was awarded to a paper containing such material.

Such a statement, in substance, must also accompany any formal publicity initiated by the author regarding the prize paper. If published elsewhere, six copies of each prize paper must be deposited shortly after publication with the office of The New York Academy of Sciences.

THE NEW YORK ACADEMY OF SCIENCES
2 East Sixty-third Street,
New York 21, N. Y.

Eunice Thomas Miner
Executive Director

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Elected December 14, 1950

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Rubinger, Joseph, M.S., Biological Sciences. Secretary, New York Scientific Supply Co., New York, N. Y.

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